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Digital Mapping, Charting, and Geodesy Analysis Program Technical Review of Vector Quantization (VQ) Decompression for the National Imagery Transmission Format Standard (NITFS)

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13. ABSTRACT *(Maximum 200 words)*

The Draft Military Standard Vector Quantization (VQ) Decompression for the National Imagery Transmission Format Standard, providing a format for images compressed via a VQ scheme, has been reviewed by the Naval Research Laboratory's Digital Mapping, Charting, and Geodesy Analysis Program (DMAP) at the request of the Oceanographer of the Navy. The written standard itself is practically complete; DMAP provides exact details on essential modifications to the document. In addition, suggested modifications and editorial comments are supplied in an effort to enhance the document. DMAP's main issue, however, is the lack of information on the relationship of this standard to the already-under-development Raster Product Format (RPF), which also provides for the compressed images and is not confined to a single compression scheme. DMAP contends that once the VQ file structure is demonstrated not to conflict with the RPF, the VQ standard will provide an acceptable format, compatible with the more comprehensive RPF, for VQ compressed images.

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Contents

Digital Mapping, Charting, and Geodesy Analysis Program Technical Review of Vector Quantization (VQ) Decompression for the National Imagery Transmission Format Standard (NITFS)

1.0 Introduction

Requested by the Oceanographer of the Navy, the Naval Research Laboratory's Digital Mapping, Charting, and Analysis Program (DMAP) has performed a technical review of the Defense Information Systems Agency's "Draft Military Standard Vector Quantization (VQ) Decompression for the National Imagery Transmission Format Standard (NITFS)" [2], in an attempt to insure that Naval requirements will be met. DMAP has observed that the scope of this document is well-defined: VQ decompression and its relationship to NITFS compliant systems. In its current form, this draft standard (referred to in this review as the VQ standard) requires few changes before becoming an acceptable standard meeting Naval requirements. The ultimate association, however, between the VQ standard and its companion documents [1], [3], and [4] should be given more consideration. In particular, the soon-to-be accepted Raster Product Format (RPF) standard [4], which is not referenced in the VQ standard despite its close relationship, should be a basis for defining the VQ file structure.

1.1 Compatibility with Raster Product Format

The relationship between RPF files and VQ files is not evident in the VQ standard. RPF supports VQ compressed images, as well as raster images compressed by other techniques or even uncompressed images. The VQ standard is much more specific and is apparently intended for use with individual images rather than general products such as Compressed ARC Digitized Raster Graphics (CADRG). If this relationship is indeed the case, it should be explicitly stated in the VQ standard.

Moreover, VQ images could not be easily read by RPF compliant software, even though that *same* image formatted in the RPF could be read. This fact is evidenced by Figures 1 to 4, where similar sections between the figures are marked for easy association. Figure 1 details an RPF frame file and Figure 2 shows the VQ file structure. Although both are similar to the NITF (Figures 3 and 4), obvious differences exist. DMAP recommends the following additions/changes to the VQ standard's [NITF image] (Figure 7 on page 13 of [2]) for at least minimal agreement with the RPF's [frame file]:

i. Add a tagged [color/grayscale section] to the image subheader;

ii. Add a [compression parameters section] to house the [image display parameter subheader];

Figure 1. RPF frame file structure taken from [4].

```
[frame file]
    {1}
    [header section]
    [location section]
    [coverage section] (0,1)
    [compression section] (0,1)
        {2}
        [compression section subheader]
            {3}
            <compression algorithm id>,uint:2
            <number of compression lookup offset records>,unit:2
            <number of compression parameter offset records>,uint:2
        {2}
        [compression lookup subsection] (0,1)
            {3}
            <compression lookup offset table offset>,uint:4
            <compression lookup table offset record length>,uint:2
            [compression lookup offset table]
                {4}
                [compression lookup offset record] (1, ... many)
                    {5}
                    <compression lookup table id>,uint:2
                    <number of compression lookup records>,uint:4
                    <number of values per compression lookup record>,uint:2
                    <compression lookup value bit length>,uint:2
                    <compression lookup table offset>,uint:4
            {3}
            [compression lookup table] (1, ... many)
                {4}
                [compression lookup record] (1, ... many)
                    {5}
                    /compression lookup value/,bits:var (1, ... many)
        {2}
        [compression parameter subsection] (0,1)
            <compression parameter offset table offset>,uint:4
            <compression parameter offset record length>,uint:2
            {3}
            [compression parameter offset table]
                {4}
                [compression parameter offset record] (1, ... many)
                    {5}
                    <compression parameter id>,uint:2
                    <compression parameter record offset>,uint:4
            {3}
            [compression parameter record] (1, ... many)
                {4}
                <compression parameter value>,byte:var
    {1}
    [color/grayscale section] (0,1)
    [image section]
        {2}
        [image description subheader]
            {3}
            <number of spectral groups>,uint:2
            <number of subframe tables>,uint:2
            <number of spectral band tables>,uint:2
            <number of spectral band lines per image row>,uint:2
            <number of subframes in east-west or left-right direction>,uint:2
            <number of output columns per subframe>,uint:4
            <number of output rows per subframe>,uint:4
            <subframe mask table offset>,uint:4
            <transparency mask table offset>,uint:4
```

Figure 1. RPF frame file structure taken from [4] (cont'd).

```
{2}
[mask subsection] (0,1)
    {3}
    [mask subheader]
        {4}
        <subframe sequence record length>,uint:2
        <transparency sequence record length>,uint:2
    {3}
    [subframe mask table] (0,1)
        {4}
        [subframe mask row] (1, ... many)
            {5}
            [subframe sequence record] (1, ... many)
                {6}
                <subframe sequence number>,uint:2
    {3}
    [transparency mask table] (0,1)
        {4}
        [transparency mask row] (1, ... many)
            {5}
            [transparency sequence record] (1, ... many)
                {6}
                <transparency sequence number>,uint:2
{2}
[image display parameters subheader]
    {3}
    <number of image rows>,uint:4
    <number of image codes per row>,uint:4
    <image code bit length>,uint:1
    <transparent output pixel code length>,uint:2
    /transparent output pixel code/,bits:var
{2}
[spatial data subsection]
    {3}
    [spectral group] (1, ... many)
        {4}
        [subframe table] (1, ... many)
            {5}
            [spectral band table] (1, ... many)
                {6}
                [image row] (1, ... many)
                    {7}
                    [spectral band line] (1, ... many)
                        {8}
                        /image code/,bits:var (1, ... many)
{1}
[attribute section] (0,1)
[related images section] (0,1)
[replace/update section] (0,1)
```

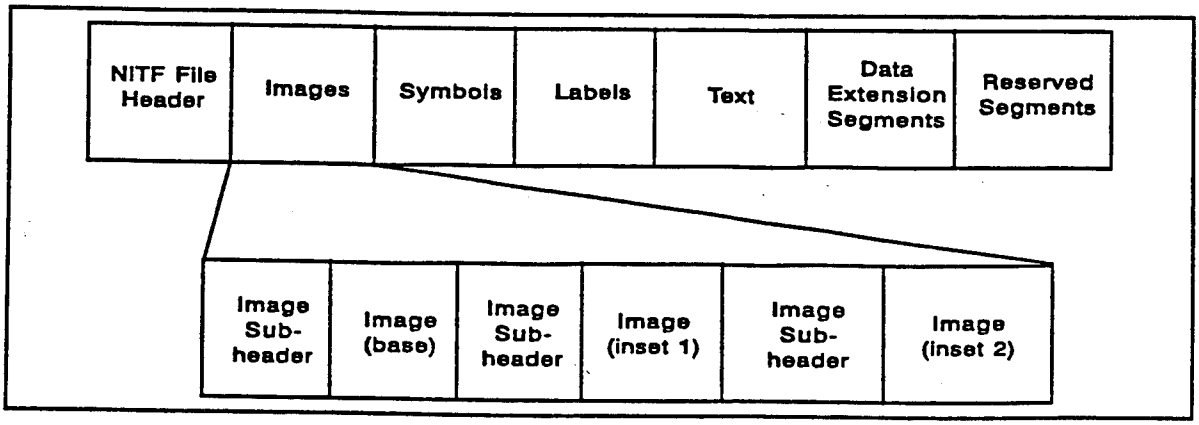
Figure 2. VQ image data structure taken from [2].

```
{1}
[nitf image data]
    {2}
    <blocked image data offset>,uint:4 (0, 1)
    [mask subsection] (0, 1)
        {3}
        [mask subheader]
        [block mask table] (0,1)
        [transparency mask table] (0, 1)
    {2}
    [VQ Header]
        {3}
        [image display parameter subheader]
            {4}
            <number of image rows>,uint:4
            <number of image codes per row>,uint:4
            <image code bit length>,uint:1
        {3}
        [compression section]
            {4}
            [compression section subheader]
                {5}
                <compression algorithm id>,uint:2
                <number of compression lookup offset records>,uint:2
                <number of compression parameter offset records>,uint:2
            {4}
            [compression lookup subsection] (0,1)
                {5}
                <compression lookup offset table offset>,uint:4
                <compression lookup table offset record length>,uint:2
                [compression lookup offset table]
                    {6}
                    [compression lookup offset record] (1, ... many)
                        {7}
                        <compression lookup table id>,uint:2
                        <number of compression lookup records>,uint:4
                        <number of values per compression lookup record>,uint:2
                        <compression lookup value bit length>,uint:2
                        <compression lookup table offset>,uint:4
                {5}
                [compression lookup table] (1, ... many)
                    {6}
                    [compression lookup record] (1, ... many)
                        {7}
                        /compression lookup value/,bits:var (1, ... many)
    {2}
    [compressed image data]
        {3}
        [spectral group] (1, ... many)
            {4}
            [block table] (1, ... many)
                {5}
                [spectral band table] (1, ... many)
                    {6}
                    [image row] (1, ... many)
                        {7}
                        [spectral band line] (1, ... many)
                            {8}
                            /image code/,bits:var (1, ... many)
```

[nitf message]
{1}
[nitf message header]
[nitf image] (0, ... many)
{2}
[nitf image sub-header]
[nitf image data]
{1}
[nitf symbol] (0, ... many)
[nitf label] (0, ... many)
[nitf text] (0, ... many)
[nitf data extension segment] (0, ... many)
[nitf reserved segment] (0, ... many)

Figure 3. NITF message structure taken from [3].

Figure 4. NITF file structure taken from [1].



iii. Increase the [compression section] to level {2}. Note: in the RPF [frame file], the [compression section] is on the same level as [image section].

These figures also show some minor differences that, once changed, could make the parallel sections correspond more closely. For instance, in Figure 1, the name [*subframe* table] is used at a structural level where the name [*block* table] appears in figure 2. Do these names and locations imply that a *subframe* in RPF corresponds to a *block* in a VQ image? If so, then the correspondence should be clarified in the RPF or VQ standard.

1.2 VQ Factors

Section 6.4 of the VQ standard states that "appropriate VQ factors" lead to high-quality images. What are these factors? Since these factors are apparently used to produce the image, will the user of VQ compressed data have access to all factors? The quantity and use of metadata (i.e., information about data) needs to be clarified in the VQ standard. If no future plans have been developed for including such information with VQ compressed images, some measure of data quality should be investigated as part of the VQ standard. The Vector Product Format (VPF), as an example, records metadata at varying levels of detail.

2.0 List of Essential and Suggested Modifications

The following list supplies comments classified as "essential" or "suggested." Page/section numbers and line/figure/table positions are given, as well as recommended alternate text.

KEY P = page L = line S = section
T = table F = figure

2.1 Essential

1. P 1 S 1.1 L 1 — Are there plans for developing a suite of standards for different types of compression/decompression, or will this be a unique standard? For example, the field IC in [1] currently has as possibilities NC or C0-C3. Will a standard be developed for each of the C0-C3? If so, this fact should be introduced in the VQ standard. As an aside note, the M4 and C4 options are not listed in [1].

2. P 1 S 1.2 L 1 — The scope of the VQ standard is contradicted by this sentence. Are *compression* details provided?

3. P 5 S 4.3 L 9 — Insert "(see figure 2)" after the sentence ending " ... field of the NITF file."

4. P 5 S 4.3 L 10 — An incorrect reference to a figure is made in this sentence: *Decompression of the VQ data is shown in figure 2.* This figure number should be 3.

5. P 5 S 4.3 L 12 — Omit the phrase "compression is achieved" from this sentence. Compression is achieved whether or not the codebook contains all possible pixel kernels.

6. P 5 F 1 — From this figure of compression process flow the color table generation and the codebook generation appear to be independent processes, both emanating from the input image data. Other figures (3, 4, and 5) and sections of text (Section 5.2.1.b, last sentence) indicate that, during decompression, color decompression occurs after spatial decompression. Figure 1 should indicate the reverse order, if it is necessary for compression as well.

7. P 7 S 4.5 L 6 — The definition of *idepth* is not phrased correctly. Idepth is the size in bytes of one color value for the input image (rather than the size of the color palette as currently stated).

8. P 7 S 4.5 L 20 — Refer to the *compression codebook* as simply *codebook*. There are multiple occurrences of compression codebook throughout the VQ standard. NRL's MDFF Laboratory uses the name *decompression codebook*.

9. P 10 S 5.2.3.2 L 2 — A precise reference to [1], page and/or section, needs to be given regarding masking as it relates to VQ images.

10. P 11 S 5.2.3.3b L 1 — The name <number of compression lookup *tables*> does not exist in figure 7.

11. P 11 S 5.2.3.3c L 1 — The name <number of compression lookup *tables*> does not exist in figure 7.

12. P 12 S 5.2.3.4e L 2 — Instead of "image subheader" the description [image display parameter subheader] should be used.

13. P 13, 14 — [Compression lookup offset record] and [compression lookup *table* offset record] are used interchangeably in figure 7 and the

definitions of the image data section. A standard name should be used.

14. P 15 S 5.4(16) L 3 [Lookup record] should be clarified with its appropriate name: [*compression* lookup record].

15. P 16 S 6.3 L 2-3 More specifics should be given regarding "orders of magnitude." What other decompression methods were used in the study?

2.2 Suggested

16. P 1 S 1.1 L 5-6 Reword this sentence as follows: "The steps involved in decompressing images compressed with VQ are fully described by this standard."

17. P 4 S 3.2v *Block* is used to represent different entities in this review. Here it's used to represent the kernel of size $v \times h$, whereas in other parts of the text (e.g., page 11, line 46 and page 6, figure 2), it's used to signify sections of an image. Two separate terms would be helpful; e.g., *kernel* and *block*.

18. P 5 S 4.2 L 1 This sentence should be more specific. For example, what types of image data are appropriately compressed using a lossy technique? More importantly, what image data are not to be compressed in this fashion? A reference to the NITFS handbook, which is referenced in [2], should be given.

19. P 5 S 4.2 L 6-7 "The codebook and the color LUT are included in the file as overhead information." NRL's MDFF Laboratory, in its construction of Compressed Aeronautical Chart (CAC), stores multiple images on CDROM, with each image stored with its own codebook and only one palette stored for each zone of images (maximum of 5 palettes per CDROM). Has this type of efficiency been investigated for "similar" VQ images? If so, are there future plans to incorporate such changes?

20. P 6 F 2 For completeness, this figure should include (but not emphasize) the information in figure 4 of this review, which shows other NITF sections such as the symbol section and label section.

21. P 6 S 4.4 L 2 — The text should read " ... input the compressed image data, which includes the image codes, codebook(s), and color table ..." to agree with figure 3.

22. P 7 L 3 — Insert "(*v x h*)" after the word "pixels" to indicate the number of kernel pixels.

23. P 7 L 14 — Insert "24-bit (3-byte)" after the word "digitized" for a better description.

24. P 7 L 15 — The codebook dimensions need clarification. This sentence could, for example, be reworded as follows: " ... codebook length of 4096 bytes with a 12 bit (1.5 byte) code_size, with 3K bytes for miscellaneous overhead, which includes an 8-bit (1-byte) color table that is 1K in size."

25. P 9 S 5.2.1b L 4 — Insert "from left to right" after the word *continue*.

26. P 10 S 5.2.3.1 — For completeness, include this description of COMRAT: *idepth* (bytes) x 8 (bits/byte) = 24 bits, divided by the theoretical compression ratio (32), yielding a *bpp* of 0.75. To be complete, Section 3.2 should define *bpp* as well.

27. P 11 S 5.2.3.3a — This section should be supplemented with an example.

28. P 11 — In the equation computing *v*, the quotient <number of image rows>, at this point in the standard, does not portray the quantity the reader expects; i.e., roughly speaking, "number of image codes in the vertical direction." The <number of image rows> should more clearly refer to compressed data.

29. P 11 S 5.2.3.4 L 2 — A definition of IMODE would be helpful, or the reader should be referred to [1].

30. P 11 S 5.2.3.4 L 9 — Rather than "NITF VQ image section" the phrase "[compressed image data] group" should be used.

31. P 12 S 5.2.3.4d L 2 — The first 64 in "64 x 64" should be noted as the determination of the 64 [image row]s.

32. P 12 S 5.2.3.4e L 2 — The second 64 in "64 x 64" should be noted as the determination of the 64 [spectral band line]s.

33. P 13 F 7 — Since <number of compression parameter offset records> is defined to be zero for VQ images (Section 5.4 (13) page 14), an indication in this figure such as "::=0" following "unit:=2" would reiterate this fact.

34. P 16 S 6.1 L 1 — More specifics should be given regarding the selection criteria and the results.

3.0 Editorial Comments

All editorial comments are included in the following list.

35. P ii S 5.2.3.1-3 — These sections have an indentation error. Also the page number "ii" is missing from the bottom of this page.

36. P iii L 12 — This Table does not appear on page 4, but on page 19. The table name should be "Data Types and Their Abbreviations."

37. P 1 S 1.5 L 2 — Omit "Vector Quantization" since Section 1.1 has already defined VQ.

38. P 2 S 2.1.1 L 11 — The "S" in NITFS represents *Standards*, whereas on the following page in Section 3.1m, the "S" represents *Standard*. Reference [1] uses *Standards*.

39. P 4 — The page number is missing.

40. P 5 S 4.3 L 11 — Replace "*compressed* image codes" with just "image codes."

41. P 7 L 7 — The symbol ")" is missing after the sentence ending " ... would be one."

42. P 10 S 5.2.2a L 1 — Replace the word *above* with the phrase "in section 5.2.1."

43. P 10 S 5.2.2a L 3 — Reference figure 2 after the phrase "NITF image subheader."

44. P 10 S 5.2.2a L 6 — The comma should be placed inside quotation marks.

45. P 11 S 5.2.3.3b L 2 — */Compression lookup values/* should be */compression lookup value/s.*

46. P 12 S 5.2.3.4d L 2 */Image codes/* should be */image code/s.*

47. P 12 S 5.2.3.4e L 2 */Image codes/* should be */image code/s*.

48. P 12 S 5.3 L 1 Insert a hyphen between STD and 2500: MIL-STD-2500.

49. P 12 S 5.3a L 4 Insert a hyphen between STD and 2500: MIL-STD-2500.

50. P 19 T 1 *Alphabetic* is misspelled: *Alaphabetic*. Also, the abbreviations could be developed in a more consistent manner. For example, sint (signed integer), uint (unsigned integer), snum (signed number), and unum (unsigned number).

4.0 Recommendations

With the few exceptions noted in this review, the VQ draft standard is a well-developed, comprehensive design. Its written exposition on VQ decompression is an improvement over that given in the CADRG specification. The lack of dependence on any one VQ compression technique further adds to its robustness. One drawback, as can be the case with such a standard, is its apparent lack of relationship to other standards in its class. For example, the RPF allows for storage of imagery compressed via a VQ technique, and yet RPF is not referenced in the document. DMAP's main recommendation: Describe the circumstances under which each will be used.

The "essential" comments noted in Section 2.0 should be incorporated into the written document. These changes will improve the standard, from both a reader and programmer point-of-view. In addition, the "suggested" comments need to be addressed before further advancement of the VQ standard. Finally, the editorial changes listed in Section 3.0 should be made.

5.0 Acknowledgments

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6.0 References

1. Defense Information Systems Agency, "Military Standard National Imagery Transmission Format (Version 2.0) for the National Imagery Transmission Format Standard," MIL-STD-2500, 18 June 1993.

2. Defense Information Systems Agency, "Draft Military Standard Vector Quantization Decompression for the National Imagery Transmission Format Standard," MIL-STD-188-XXX, 15 February 1994.

3. Defense Mapping Agency, "Draft Military Standard Integration of Raster Product Format Files into the National Imagery Transmission Format," MIL-STD-2411-2, 22 December 1993.

4. Defense Mapping Agency, "Draft Military Standard Raster Product Format," MIL-STD-2411, 27 December 1993.

Appendix. Acronyms.

bpp	bits per pixel
CAC	Compressed Aeronautical Chart
CADRG	Compressed ARC Digitized Raster Graphics
DMAP	Digital Mapping, Charting, and Geodesy Analysis Program
MDFF	Map Data Formatting Facility
NITF	National Imagery Transmission Format
NITFS	National Imagery Transmission Format Standard
NRL	Naval Research Laboratory
RPF	Raster Product Format
VPF	Vector Product Format
VQ	Vector Quantization